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*THE PREVALENT DISEASES IN THE PHILIPPINES.**

WE have the honor to submit to you a brief account of our work and movements in carrying out your commission to study the prevalent diseases in the Philippine Archipelago. Your commissioners, consisting of Dr. Simon Flexner and Dr. L. F. Barker, to whom were voluntarily attached Messrs. J. M. Flint and F. P. Gay, of the Medical School, the latter having given their time and paid all their own expenses, sailed from Vancouver on March 29, 1899, and arrived in Manila, May 4th, where they immediately established themselves for the purpose of the work mentioned. Owing to the military situation it was found impracticable to visit other ports in the Archipelago, or to penetrate into the interior of the Island of Luzon. The entire time, therefore, of the commission was spent in the study of disease existing among the natives and American troops in Manila and at Cavite.

WORK IN JAPAN AND HONG-KONG.

As transport sailings were uncertain and the passage out by them slow, it was decided to save time and go by fast steamer, the Canadian Pacific Railway giving es-

* Report upon an expedition sent by the Johns Hopkins University to President Gilman, Doctors Welch and Osler, Philippine Committee of the Johns Hopkins University Medical School.

pecial rates to the commission on tickets around the world.

The original plan of your commissioners was to proceed directly to Manila by way of Hong-Kong, at which latter port it was intended to stop only long enough to outfit for the tropics and to catch the earliest steamer sailing for Manila. After consideration of the probability that certain new kinds or phases of disease, not occurring in temperate regions, might be encountered in the Archipelago, and of the fact that the diseases of the Philippines would probably have much in common with those of Japan, it was decided to spend one week in Japan, where modern hospitals could be visited and advantage taken of the results of the study of tropical disease by highly trained and eminent Japanese physicians. The decision proved to be valuable in many ways; and we especially desire to express our obligations to Professors Aoyama, Mitsukuri, Miura and Kitasato, who showed us many courtesies. The opportunity to see in the Japanese hospitals pure and mixed examples of beri-beri assisted us greatly in our subsequent studies, as did also the observations on dysentery made in the Institute for Infectious Diseases at Tokio.

While outfitting at Hong-Kong we improved the opportunity to study the bubonic plague, which was still prevailing at that port. This study was made easy by the generosity and courtesy of the English Civil Physician, Dr. James Lowson, in charge of the Plague Hospital and Mortuary. The study begun in this way was extended when two months later we returned to Hong-Kong, en route to America. At this time a considerable exacerbation of the disease had taken place, and within a week or ten days we saw several scores of cases and performed many autopsies. The several forms of infection: inguinal; axillary; tonsillar and cervical and pulmonary, were thus encountered. Bacteriological examinations were made and tissues collected for future study. Two of the party (Dr. Barker and Mr. Flint) spent on the return journey three weeks (at their own expense) in India, where the great epidemics of plague there raging were observed.

ARRIVAL IN MANILA.

Immediately upon our arrival in Manila quarters were sought at the 'Hotel de Oriente.' Very insufficient accommodations were secured for a limited time, as the sudden accession of families of Army and Naval officers had strained the hotel to its fullest capacity. Having been forewarned of the conditions of living in Manila, we took the precaution to bring with us from Hong-Kong a group of Chinese servants, intending to set up house-keeping if practicable. After much difficulty a small house was secured in San Miguel, where, by hiring parts of the furnishings and buying what could not be rented, a temporary establishment was secured.

Within a few hours after our arrival the credentials and private letters brought were presented to Colonel Woodhull, Surgeon-in-Chief to the 8th Army Corps and to General Otis. Colonel Woodhull afforded us every opportunity to prosecute our work in the military hospitals. Although no special introduction was in our possession, we quickly met Dr. Bournes, chief health officer of Manila, who opened to us the hospitals under his charge. Somewhat later we met Dr. Pearson, Chief Naval Surgeon, who opened the Naval Hospital at Cavite to us.

HOSPITALS AT MANILA.

Civil Hospitals.—These consist of a large hospital within the walled city, *San Juan de Dios.* It has a capacity of from 250 to 300 beds and accommodated during our stay both natives and Europeans. The number of European patients was small. When the military hospitals were much

crowded a certain number of wounded prisoners of war were accommodated. The hospital contained chiefly native medical cases of both sexes. The *San Lazaro* or leper hospital, in the outskirts of Manila, contained from 80 to 100 lepers during our stay. These had come from Luzon, almost exclusively from Manila and its immediate surroundings. The two sexes are provided for in separate, large and airy wards. One wing of the building, having a private entrance, is devoted to native prostitutes who apply regularly for examination and are incarcerated here and treated medically when found to be suffering from venereal disease.

Military Hospitals.—These consisted, beside the regimental hospitals which were virtually detention camps, of three Reserve Hospitals—the 1st, 2d and 3d Reserve Hospitals; a convalescent hospital on Corregidor Island and the Hospital Ship *Relief*, which was anchored in the bay. The First Reserve Hospital, under the control of Major Crosby, had been originally the Spanish military hospital. It had been from time to time, by the erection of tents over platforms raised a foot or two from the ground, increased in capacity until in July it contained 1200 or more beds. The Second Reserve Hospital, under the control of Major Keefer, was a transformed modern school building and because of its limited capacity (250 beds), high ceilings and wide corridors it made a model hospital. The Third Reserve Hospital had just been established towards the end of our visit and was smaller than the others and intended as a convalescent hospital. The hospital at Corregidor is a temporary structure and intended for convalescents. It is especially well adapted for its purpose because of the high and hilly character of the island and its complete investment by the sea. The *Relief* was used as a hospital for acute cases; but some time before we left the acute cases were transferred to the Reserve Hospitals and the *Relief* sailed for San Francisco with invalided men.

The Reserve Hospitals accommodated especially American sick and wounded; but a ward in the First Reserve Hospital was set aside for the Filipino wounded.

After the outbreak of beri-beri at Cavite a hospital under military control was established at San Roque in the remains of the Spanish Marine Hospital which had been wrecked by the insurgents.

Naval Hospital.—A small hospital for sick seamen and marines was established at Cavite. Through the courtesy of Dr. Pearson this was open to us for clinical studies.

Clinical Pathological and Bacteriological Laboratory.—Through the kindness of Colonel Woodhull and Major Crosby, the officer-in-chief of the First Reserve Hospital, a small Filipino house, situated on the banks of the Pasig, was given us in which to establish a laboratory. This was done on the second floor of the house. The expense of putting up working tables was kindly borne by the Medical Corps of the Army. The laboratory equipment was set up in this building and within a very few days after our arrival work was begun. We desire to speak of the co-operation of the Medical Staff of the hospital who afforded us every opportunity to visit the wards and many of whom joined or assisted us in clinical and pathological work. We wish especially to acknowledge the co-operation and assistance of Lieut. Richard P. Strong, a graduate of the J. H. U. Medical School, who had on our arrival already begun to do laboratory work and who gave up much of his valuable time in furthering our interests. It was found unnecessary to establish laboratories in the other hospitals, in the first place because all were connected with the Frst Reserve by the Signal Service telegraphic system of which we had free use; and next because all the dead were carried to the morgue in

conjunction with the First Reserve Hospital. We went or were frequently called to the other hospitals to make clinical and bacteriological examinations.

With few exceptions, all the dead were subject to autopsy. Post-mortem examinations were made at the Civil Hospitals upon natives and at the Military Hospital upon all that died. Exceptions were made only in the cases of those dead from gunshot wounds, when, if pressed for time, necropsies were sometimes omitted.

PREVAILING DISEASES.

The subject of the prevalent diseases may be considered as they affect (1) the natives, and (2) Europeans and Americans, especially the American garrison.

Diseases affecting Natives.—(*a*) *Skin Diseases.* Of the skin diseases prevailing among the natives, aside from smallpox and other specific exanthemata, may be mentioned (1) diseases of the scalp, which are very frequent; (2) dhobie itch; and (3) an affection which resembles closely and which is probably identical with Aleppo boil (Delhi boil, Biskra button, *epidemische Beulenkrankheit*). (*b*) *Smallpox.* This disease has been so generally prevalent in Luzon that the natives have to a large extent lost fear of it. All evidence points to the greatest carelessness in preventing its spread during Spanish times. Isolation of the sick and disinfection of the habitations seem not to have been attempted, and vaccination, even among the Spanish garrison, had not been carried out. Under these circumstances it could be no surprise that after the American occupation the disease should appear and even become epidemic. The epidemic which appeared early last year was promptly met by Br. Bournes, who caused the Spanish garrison still in Manila and the natives and Chinese within the city to be vaccinated. In order to insure satisfactory results he found it necessary to establish a vaccine farm in which young *carabao* were used for the preparation of the virus. Under the influence of this measure and by the aid of isolation of the sick the disease had in May practically disappeared within the military lines about Manila. (*c*) *Leprosy.* A definite focus of this disease exists in Luzon. The cases, in the neighborhood of 100, which were confined in the San Lazaro Hospital came from Manila and the country immediately surrounding that city. The disease affected both sexes, being more frequent in adults, although also present in half-grown boys and girls. The commonest forms were the tubercular and mutilating. Autopsies were performed upon several cases that had died during our stay. (*d*) *Tuberculosis.* Accurate statistics of the extent of the prevalence of this disease are difficult if not impossible to obtain. That the disease is a common one is indicated by several facts. It is frequently met with in the native hospitals, where it may have been recognized during life or is disclosed at autopsy. Many cases of supposed beriberi which we autopsied at San Juan de Dios proved to be tuberculosis. It is possible that the two diseases had co-existed, for we found such combinations freely recognized by Japanese physicians in the hospitals in Japan. Tuberculosis of the lungs was also found as a common complication in leprous individuals that came to autopsy. A not very infrequent spectacle met with on the streets are much emaciated and weak natives, affected with suggestive coughs and free expectoration. While it is not certain that these individuals were examples of tuberculosis, there is strong probability that this explanation of their condition is the correct one. (*e*) *Venereal Disease.* Syphilis, by general agreement (statistics not available), does not prevail unduly. Chancroids and gonorrhœa are, on the other hand, very common. The majority of the prostitutes confined

in the San Lazaro were victims of these two diseases. A very common complication of the soft sore, owing to lack of cleanliness, is swelling and suppuration of the inguinal glands. (*f*) *Beri-Beri.* This disease is well known among the natives. It would appear to be epidemic and endemic in Luzon. It is, judging from cases met with in San Juan de Dios Hospital and the statements of native physicians, constantly appearing in a sporadic form. During our stay an epidemic appeared among the Filipino prisoners confined at Cavite. Some 200 cases developed in a few weeks; the mortality ranged from 20 to 30 per cent. The several recognized forms of the disease —œdematous, paralytic, and mixed—were encountered. Clinical and bacteriological studies were made upon the living, and the dead were subjected to autopsy and bacteriological examination. The difficulty of getting to and fro between Manila and Cavite on account of the impossibility of land communication, made this part of our work difficult and time-consuming. A considerable collection of pathological material and other data has been made. This material is now in process of study and arrangement.

Diseases affecting Americans.—The chief causes of disability among the American land forces are the enteric diseases. These are diarrhœa, dysentery, typhoid fever, and gastro-intestinal catarrhs. Many of the diarrhœas are merely preliminary to the symptoms of dysentery. Other infectious fevers are relatively infrequent. A small number of cases of scarlet fever and diphtheria only were encountered. The malarial fevers prevailed but not seriously during the months of May, June and July. (*a*) *Dysentery.* This disease is responsible for the greatest amount of invalidation and the highest mortality. It appears in acute, sub-acute, and chronic forms. The chronic form is sometimes attended by secondary abscess of the liver. The acute form may end in 24, 48, or 72 hours. In it the whole of the large intestine and usually the lower portion of the ileum is involved. The mucous membrane of the gut is swollen, congested and œdematous, in places hemorrhages have taken place into the mucous membrane and the sub-mucosa is swollen and its blood-vessels greatly dilated. No ulcers existed in such cases. Amœbæ were absent or very difficult to find in the fresh stools and in the intestinal contents immediately after death. In the sub-acute and chronic forms ulcers are present in the mucosa; the coats of the intestine are greatly thickened; at times large sloughs of mucous membrane, partly detached, occur, and the lesions are confined to the large intestine. Amœbæ are more commonly present in these cases but are variable as to actual occurrence and numbers. Large hepatic abscesses, usually single, were encountered in a number of these cases. Amœbæ were variable in the contents of the abscesses. In one very large abscess, occupying both right and left lobes of the liver, no amœbæ but a pure culture of the Staphylococcus pyogenes citreus was obtained. The clinical study of the cases of dysentery with reference to amœbæ was equally unsatisfactory. In cases with marked symptoms both in patients confined to bed and those beginning to go about but still with persistent loose bowels, these organisms were frequently missed; while in instances ready to be discharged they might, at certain examination, be found to be very abundant. In morphology, the amœbæ studied corresponded with the amœba coli found in Egypt and in this country. The bacteriological study of cases of dysentery was carried out upon the fresh stools of acute and chronic cases and with the intestinal contents, mesenteric glands, liver, etc., of cases dying and subjected to autopsy. The intestinal flora was studied in its entirety by means of plate cultures.

A variety of micro-organisms were separated. Many of these were well-known species or occurred normally in the situations in which found. Tests with blood sera for agglutination were made and those organisms giving positive reactions were separated for further study. Two groups of bacilli were thus differentiated: (1) Having affinities with the group of bacillus coli communis. The agglutination was variable, being constant and sensitive with the blood-serum of the same individual (host) and inconstant, and active in relatively strong solutions only, in serum from other individuals. (2) Having affinities with the group of bacilli of which bacillus typhosus is the type. Agglutination constant and sensitive with blood-serum of host as well as the sera of other individuals suffering from dysentery. Inactive with normal serum, serum from cases of typhoid fever, malaria and beri-beri. A bacillus belonging to the second group, which is still under study, would seem to agree with the bacillus dysenteriæ isolated by Shiga from cases of endemic dysentery occurring in Japan. It is regarded by us as an important factor in the causation of the dysentery of the Philippine Islands. Experiments in immunization of animals and the production of vaccine are in progress. (*b*) *Typhoid fever.* The total number of cases of typhoid fever in the hospitals during May, June and July was far below those of dysentery; the number of deaths also was less. It was, however, a frequent affection among Americans. The examination of the blood, microscopically and with the Widal test, was of the greatest help in diagnosis. The disease came to autopsy presenting the classical intestinal lesions and also in atypical forms. In the small number of autopsies made upon those dead of this disease, several instances of slight intestinal envolvement or even entire escape were met with. These cases would have remained very obscure or even undetermined except for the Widal reaction and bacteriological examination. In some instances the typhoid bacillus was found widely disseminated throughout the body, the autopsy being made immediately after death. (*c*) *Malarial Fevers.* A large proportion of the cases sent in from the field and outlying military stations where examinations had to be hastily made as instances of 'malaria' or 'intermittent fever' turned out to be cases of other diseases (typhoid, dysentery, etc.). A number of true cases of malarial fever were, however, met with, and in the blood of these the characteristic parasites, identical with those occurring in other places in which studies of the blood have been made, were found. No quartan parasites were met with, but cases of quartan affection doubtless exist. Typical infections with the 'tertian' and 'æstivo autumnal' varieties of the parasite were encountered by us, and by microscopists among the Army physicians in the Reserve Hospitals and on the *Relief*. One of the fatal cases of malaria was complicated with acute lobar pneumonia. The cases of 'calentura perniciosa' which occur in Mindoro, Mindanao and in certain parts of Luzon should be studied as soon as these regions are accessible. The Archipelago is favorable also for the study of the relation of mosquitos and other insects to malarial infection. Some of the malarial cases were undoubtedly *recidives*, imported from Cuba or elsewhere. A very small number of deaths was referable to malaria. Two instances of acute malarial infection came to us for autopsy. On the other hand, several instances of malarial pigmentation of the organs, in persons dying from other diseases, were encountered. Parasites in the latter cases were absent. These men had, as a rule, been in Cuba or Puerto Rico during the Spanish war.

(*d*) *Tuberculosis.* A number of cases of

pulmonary tuberculosis developed among the soldiers in the American troops. A definite history of exposure to wet and various hardships was elicitable in many of these cases.

(*e*) *Dengue.* At Cavite there occurred a large outbreak of an epidemic fever of short duration (a few days) known locally as Cavite fever. Almost all who remained in Cavite for any length of time were attacked. Second and third attacks were common. Muscular pains were severe in some cases and not in others. A slight exanthem was present in many of the cases. Flushing of the face, restlessness and general malaise accompanied the fever and rapid heart action. Malarial parasites were not present in the blood, nor did the serum from such cases agglutinate cultures of the typhoid bacillus. The epidemic is regarded as one of Dengue.

(*f*) *Tropical Ulcers.* A number of the American soldiers suffered from a form of indolent ulceration, locally known as 'tropical ulcer.' These ulcers occurred singly sometimes but were more often multiple. They began as small pustules, which gradually extended. They were most frequent among those who had been compelled to make long marches through swampy districts, and the patients themselves attributed the ulceration to 'poisoning' in the marshes.

(*g*) *Wound Infection.* Our experience with wound infections was rather limited. The other problems undertaken, regarded as more important as bearing on the general question of disease and its causation in the Islands, left but little time and opportunity to attack this interesting subject. Certain observations of interest were made. Pyogenic infections due to the common pus cocci occurred. In a small number of gunshot wounds causing compound fractures emphysematous gangrene occurred and the bacillus aerogenes capsulatus was isolated. In one instance of compound fracture of the tibia a spore-bearing bacillus was associated with the bacillus aerogenes capsulatus. It was found in cover-slip preparations from the original wound in the first set of cultures. It could not be further transplanted and hence was not identified. In two other cases was the bacillus aerogenes met with, one a case of peritonitis following infection of the intestine from an incarcerated hernia, and the other also a case of peritonitis but secondary to perforation of a typhoid ulcer of the intestine. The army surgeons were enthusiastic as to the adequacy of the 'First-Aid Package' in limiting the number of wound infections.

CLIMATOLOGICAL AND HYGIENIC CONDITIONS.

The climate is that of continual summer. There is a wet season (S. W. Monsoon) and a dry season (N. E. Monsoon). The hottest period is at the end of the dry and the beginning of the wet season—precisely the period of our visit. The climate from November to March is said to be delightful. In the worst season of the year the climate is very trying and especial precautions are to be taken if Americans are to keep well there. The extremes of temperature are not great, but the constancy of the high temperature, together with a high degree of humidity, make the climate peculiarly enervating. We were interviewed at length while in Manila, officially by the U. S. Philippine Commission, with regard to climate and the hygienic precautions to be observed, as well as with regard to other medical problems in the islands. The climatic conditions and the hygienic precautions to be taken will form the subject of a fuller report to be made later.

The above represents, briefly stated, the results achieved by your expedition sent to the Philippines. As will be patent to you, not a little yet remains to be done before the scientific portion of the work is completed. This portion of the report is for the present only hinted at or withheld until

it shall have been finished. It is the intention of your commissioners to make careful studies of the material relating to beri-beri, dysentery, malarial and typhoid fevers, leprosy, and the bubonic plague, which has been collected. These studies, with the exception of that relating to dysentery, will be carried out upon preserved material, and the labor involved, which has been divided between Baltimore and Philadelphia, will necessitate that some time must elapse before the finished report is forthcoming. The task of completing the study of the bacillus isolated from cases of dysentery has been assigned to Dr. Flexner, who was principally engaged with that theme during the residence in Manila. In order to carry out the experiments as designed, an outlay for experimental animals and their maintenance will need to be made. It is known to you that the original sum so generously contributed by friends of the University and appropriated for the use of your commission has been exhausted, and that private means have been drawn upon to defray a part of the expense involved. We would respectfully draw attention to this fact and to the further expenses to be incurred, and request direction as to your wishes regarding these matters.

We wish to express our deep gratitude to Messrs. Flint and Gay, whose untiring efforts during our residence in Manila made it possible to accomplish far more than we could have done unaided. It is a pleasure to acknowledge also many kindnesses on the part of Mr. John W. Garrett.

That we are deeply indebted to the officers in the Medical Service of the U. S. Army and Navy for opportunities and aid is evident from the report preceding. Courtesies and kindnesses extended by various citizens of Manila, European and native, are here also gratefully acknowledged.

Simon Flexner,
Lewellys F. Barker.

*A POPULAR ACCOUNT OF SOME NEW FIELDS OF THOUGHT IN MATHEMATICS.**

At the beginning of the nineteenth century elementary arithmetic was a Freshman subject in our best colleges. In 1802 the standard of admission to Harvard College was raised so as to include a knowledge of arithmetic to the 'Rule of Three.' A boy could enter the oldest college in America prior to 1803 without a knowledge of a multiplication table.† From that time on the entrance requirements in mathematics were rapidly increased, but it was not until after the founding of Johns Hopkins University that the spirit of mathematical investigation took deep root in this country.

The lectures of Sylvester and Cayley at Johns Hopkins University, the founding of the *American Journal of Mathematics* and the young men who received their training abroad co-operated to spread the spirit of mathematical investigation throughout our land. This led to the formation of the American Mathematical Society eight years ago as well as to the starting of a new research journal, *The Transactions of the American Mathematical Society*, at the beginning of this year. While these were some of the results of mathematical activity, they, in a still stronger sense, tend to augment this activity.

In Europe such men as Descartes, Newton, Leibniz, Lagrange and Euler laid the foundation for the development of mathematics in many directions. These men, as well as a few of the most prominent in the early part of the nineteenth century, were not specialists in mathematics. They were familiar with all the fields of mathematical activity in their day and some of them were well known for their contributions in other fields of knowledge. The last

* Read at the regular winter term meeting of the Alpha Chapter of Sigma Xi, Cornell University.

† Cajori, The teaching and history of mathematics, 1890, p. 60.

three-quarters of a century and especially the last two or three decades have witnessed a marvelous change in the mathematical activity of Europe. Mathematical periodicals have sprung up on all sides. A number of mathematical societies have been organized and many of the leading mathematicians have confined their investigations to comparatively small fields of mathematics.

The rapid increase of the mathematical literature created an imperative need of bibliographical reviews. This need was met in part by the establishment at Berlin, in 1869, of a year-book devoted exclusively to reviews of mathematical articles, *Jahrbuch über die Fortschritte der Mathematik*. The 28th volume of this work reached our library a short time ago. It contains over 900 pages. With a view towards further increasing the facilities to keep in touch with this growing literature, the Amsterdam Mathematical Society commenced the publication of a semi-annual review, *Revue Semestrielle*, in 1893. In the last number, 236 periodicals are quoted, each of which contains, at times, mathematical articles that are of sufficient merit to be noted. Each of the four countries, France, Germany, Italy, and America publishes over thirty such periodicals.

One of the characteristic features of our times is the prominence of the spirit of co-operation. The mathematical periodicals and the mathematical societies are evidences of this spirit. In quite recent years international mathematical congresses have given further expression of the wide-spread desire to co-operate with even the most remote workers in the same fields. The first of these congresses was held in Zurich in 1897, and the second is to be held during the coming summer in connection with the Paris Exposition. The same spirit led in 1894 to the starting of a periodical, *L'intérmediare des mathématiciens*, which is devoted exclusively to the publishing of queries and answers in regard to different mathematical subjects.

This desire for extensive co-operation is tending towards unifying mathematics and towards laying especial stress on those subjects which have the widest application in the different mathematical disciplines. This explains why the theory of functions of a complex variable and the theory of groups are occupying such prominent places in recent mathematical thought.*

Before entering upon a description of some of the fields included in these subjects and the interesting problems which they present, it may be well to state explicitly that our remarks on mathematics will have very little reference to its application to other sciences. To the pure mathematician a result that has extensive application in mathematics is just as important and useful as one which applies to the other sciences. Mathematics is a science which deserves to be developed for its own sake. The thought that some of its results may find application in other sciences is, however, a continual inspiration, and those who investigate such applications sometimes add materially to the development of mathematics.

The curve representing a function of a single variable was the principal object of investigation during the eighteenth and a great part of the nineteenth century.† The investigations of Abel and Cauchy on power series during the early part of the nineteenth century furnished the foundation for the modern theory of analytic functions—a theory which has been adorned by the labors of some of the most brilliant mathematicians of the preceding generation and which is claiming the attention of some of the foremost thinkers of the present time. Quite recently this theory has been made

* Cf. Klein, *Chicago Mathematical Papers*, 1893, p. 134.

† Lie, *Leipziger Berichte*, vol. 47, p. 261.

more accessible to English readers by the treatises of Forsyth and of Harkness and Morley.

The critical spirit of our age is, in a large measure, due to the study of the theory of analytic functions. "Newton assumes without hesitation the existence, in every case, of a velocity in a moving point, without troubling himself with the inquiry whether there might not be continuous functions having no derivative."* When it was discovered that such functions exist and that the works of some of the greatest mathematicans of the preceding centuries have to be modified in some instances, mathematicians naturally became much more exacting in regard to rigor, and thus ushered in an age which may be compared with the times of Euclid with respect to its demands for rigor. Whether our critical age will produce a work which, like Euclid, will serve as a model for millenniums cannot be foretold, but it seems certain that works which can stand the critical tests of this age will stand the tests of all ages.

The critical spirit of our times is the foundation of what has been styled the *arithmetization of mathematics*. This movement which the late Weierstrass knew so well to lead is pervading more and more the whole mathematical world. We are rapidly banishing from our treatises the term quantity and replacing it by the word number. Our geometric intuitions are forced into the background and logical deductions from definitions are taking their places. Who can conceive of curves which have no tangent at any of their rational points in a given interval? Nevertheless it is well known that such curves exist. An account of such functions was first published by Hankel in 1870.†

Mathematicians find themselves in a great dilemma at this point. Geometric intuition has been such a strong instrument of research and has given so much life and beauty to mathematical investigation that mathematicians cling to it, as their own lives. It is an enormous price when rigor can be purchased only with geometric intuition. Yet, in the present stage of mathematical thought, this seems to be the only thing that will be accepted, and mathematicians stand helpless before this decree.

A few examples may throw some light on this subject. What do we understand by the length of a continuous curve? The intuitionalist says, if we connect different points of the continuous curve by straight lines and find the sum of the lengths of these straight lines, then the length of the curve will be the limit of this sum as the number of the points is indefinitely increased. Jordan was the first to call attention to the fact that this sum need not have a limit. Hence there are continuous curves which do not have any length according to the ordinary definition of length. In fact a number of area-filling curves have recently been studied, and Cantor has shown that a multiplicity of any number of dimensions can be put in a one to one correspondence with a multiplicity of one dimension.

These are some of the facts which have compelled mathematicians to construct their own worlds—the number worlds. Conclusions drawn in one number world do not necessarily apply to another. When a problem is under consideration the number world is so chosen as to meet the demands of the problem. For instance, the constructions and demonstrations of Euclid's geometry seem to require only a space composed of quadratic numbers.* Hence it appears that we do not need to assume that space is continuous in order to demonstrate the theorems of elementary geometry. Simi-

* Klein, *Evanston Colloquium*, 1894, p. 41.

† Cf. Pierpont, *Bulletin of the American Mathematical Society*, vol. 5, p. 398.

* Cf. Strong, *Bulletin of the American Mathematical Society*, vol. 4, 1898, p. 443.

larly in algebra, we are laying more and more stress upon a distinct statement of the number world (the domain of rationality) in which we are operating. Such specifications add a clearness and rigor to our work which would otherwise scarcely be possible.

This refinement which the mathematical thought of to-day is so actively cultivating is not restricted to the finite region. Mathematical infinity is receiving its share of attention. It is well known that it is sometimes desirable to regard the infinite region as a single point. This is, for instance, the case in the transformation known as inversion. Again, in ordinary projective geometry it is generally convenient to regard the infinite region as of one lower dimension than the finite, so that the infinite region of a plane is merely a line and the infinite region of space is a plane. The student of differential calculus is, moreover, familiar with the infinite variable and the many simplifications which its uses make possible.

The most fruitful investigations along this line are those on multiplicities (Mengenlehre, ensembles). Any total of definite and clearly defined elements is said to form a multiplicity. If two multiplicities are simply isomorphic, *i. e.*, if there is a 1, 1 correspondence between the elements of the multiplicities, they are said to be equivalent, or to have the same power. For example, it is easy to prove that all the positive rational numbers are equivalent to the natural numbers. To do this we may associate all the rational numbers p/q for which the sum $p+q=n$ any positive integer. We thus have the $n-1$ numbers.

$$\frac{n-1}{1}, \quad \frac{n-2}{2}, \quad \frac{n-3}{3}, \quad \cdots, \quad \frac{2}{n-2}, \quad \frac{1}{n-1}.$$

We may let 1 correspond to 1; the numbers for which $n=3$ correspond to 2 and 3; the numbers for which $n=4$ correspond to 4, 5 and 6, etc. We thus obtain the following 1, 1 correspondence between all the rational numbers and the positive integers:

$$\tfrac{1}{1}; \tfrac{2}{1}, \tfrac{1}{2}; \tfrac{3}{1}, \tfrac{2}{2}, \tfrac{1}{3}; \tfrac{4}{1}, \tfrac{3}{2}, \tfrac{2}{3}, \tfrac{1}{4}; \tfrac{5}{1}, \tfrac{4}{2}, \tfrac{3}{3}, \tfrac{2}{4}, \tfrac{1}{5}; \cdots$$

$$1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, \cdots$$

It may be observed that we do not need to reduce the rational fractions to their lowest terms to effect this correspondence. This method of proof is due to Cantor, who has also proved that all algebraic numbers are equivalent to the natural numbers.* How important and far-reaching the investigations along this line are may be inferred from the fact that Jordan has employed them to serve as a foundation of the elementary part of the second edition of his magistral 'Cours d'analyse.'

A large number of mathematical problems may be reduced to equations involving a single unknown. The solution of such equations has occupied a prominent place in the mathematical literature for centuries. The problem is so difficult that it has been attacked from a number of different points and by means of a large variety of instruments. The instrument which has proved to be the most powerful and far-reaching is substitution groups. By means of it Abel succeeded in 1826 to prove that an equation whose degree exceeds four cannot generally be solved by the successive extraction of roots† and Galois a few years later sketched a far-reaching theory of equations which rests upon the theory of these groups.

In recent years it has been recognized (especially through the labors of Sophus Lie) that the theory of groups has very extensive and fundamental application in a large number of the other domains of mathematics. About a year ago the great French mathematician H. Poincaré showed in an article, published in the Chicago *Monist*‡ how this concept may be employed in laying the foundations of elementary

*Cantor, *Crelle*, vol. 77, 258; cf. vol. 84, p. 250.

†*Crelle*, vol. 1.

‡October, 1898.

geometry. It should be observed that the theory of groups is intrinsically based upon the fundamental concepts of mathematics. It is not a superstructure. It stands on its own foundation and supports more or less a number of other mathematical structures.

As this theory is less known than most of the other extensive branches of mathematics it may be desirable to enter into some details. It is evident that there are rational functions of n independent variables $(x_1, x_2, x_3, \cdots, x_n)$ which are not changed when these variables are permuted in every possible manner. Such functions are said to be symmetric in regard to these variables. The sum of any given power of these variables $(x_1^a+x_2^a+x_3^a+\cdots+x_n^a)$ is an instance of a symmetric function. These functions occupy one extreme. The other extreme is furnished by functions such as $x_1+2x_2+3x_3+\cdots nx_n$ which change their value for every possible interchange of the variables. Most of the functions are of neither of these extreme types.

Suppose that a function $\varphi(x_1, x_2, \cdots, x_n)$ is not changed by either of two interchanges of its independent variables. Such interchanges are called substitutions and they may be represented by S_1 and S_2. Since φ is not changed by either of the substitutions S_1, S_2, it cannot be changed by the substitutions which are equivalent to the succession of these substitutions taken in any order. All such substitution may be represented by $S_1^\alpha S_2^\beta S_1^\gamma S_2^\delta \cdots$.* Since only a finite number of permutations are possible with n letters it follows that $S_1^\alpha S_2^\beta S_1^\gamma S_2^\delta \cdots$ can represent only a finite number of distinct substitutions. The totality of these substitutions is said to be a *substitution group*. Hence we observe that every rational function belongs to some substitution group.

It was soon observed that an infinite number of functions belong to the same substitution group and that all of these functions can be expressed rationally in terms of one of them. The researches of Abel, Galois, and Jordan, were based upon these facts and they show that the most important problems in the theory of equations involve the theory of substitution groups. The theory of groups was thus founded with a view to its application to a subject of paramount importance. A broad mathematical subject can, however, not grow vigorously and harmoniously as long as it is studied with a view to its direct applications to other mathematical subjects. It must be free to expand in all directions. That freedom for which the human race has ever been struggling must be vouchsafed to such fundamental subjects before they will exhibit their great fertility and far reaching connections. Less than three years ago the first work on the theory of groups that does not consider its application * was given to the public, but the mathematical journals have been publishing a large number of memoirs along the same line for a number of years.

In defining a substitution group we implied only two conditions; viz, no two substitutions of the group are identical and if we combine the substitutions in any way we obtain only substitutions which are already in the group. Substitutions obey *per se* some other conditions; *i. e.*, when they are combined (multiplied together) they obey the associative law and if we multiply a substitution by (or into) two different substitutions the products will be different. In general we say that any finite number of operations which obey these four conditions constitute a group; *e. g.*, all the rotations around the center of a regular solid which make the solid coincide with itself constitute a group, the n n^{th} roots of unity constitute a group with respect to multiplication but not with respect to addition, etc.

* The exponent indicates the number of times the substitution is employed in succession.

*Burnside, 'Theory of groups of a finite order,' 1897.

While the bulk of the mathematicians are reveling in the new fields of thought which are opening up on all sides, without any thought in reference to any immediate practical application of their results, there is fortunately a goodly number whose main efforts are devoted towards making some of these new results useful to the investigators in some of the other sciences. As an instance of fairly recent work of the latter kind, we may mention the study of linkages with a view towards describing a straight line. Although the straight line is of such fundamental importance both in pure and applied mathematics, yet it seems it was not until the latter half of the nineteenth century that a mechanical device was discovered by means of which such a line can be described.

In 1864 M. Peancellier, an officer of engineers in the French army, discovered the well known device to describe a straight line by means of an instrument composed of seven links. "His discovery was not at first estimated at its true value, fell almost into oblivion, and was rediscovered by a Russian named Lipkin, who got a substantial reward from the Russian government for his supposed originality. However M. Peancellier's merit was finally recognized and he has been awarded the great mechanical prize of the Institute of France, the Prix Montyon."*

Although the straight line and the circle occupy such a prominent place in elementary geometry and have been before the eyes of the mathematicians for thousands of years, yet less than half a century has passed since the invention of a mechanical device by means of which the straight line can be drawn. Such discoveries go far towards emphasizing the need of investigations even in the most elementary subjects. Such investigations should, however, be preceded by a thorough knowledge of what has been done along the same lines.

If elementary mathematics is to continue to furnish the best possible preparation for the study of advanced mathematics, it is evident that it has to adapt itself to the rapid changes which are going on in the different branches of mathematics. A need is thus created for elementary text-books which meet the new requirements, and we are happy to be able to state that such books are being produced in our midst. How radical such changes may become cannot be foretold. In his address before the New York Mathematical Society, Simon Newcomb said, "The mathematics of the twenty-first century may be very different from our own; perhaps the schoolboy will begin algebra with the theory of substitution groups, as he might now but for inherited habits."* It is to be hoped that our inherited habits will not furnish an insurmountable barrier to progress in this direction.

In modern times the continent of Europe has always been the most progressive and most of the new theories were first developed in these countries. The theory of invariants seems to be an exception to this rule. The two great English mathematicians, Cayley and Sylvester, developed this theory with great vigor; when their important results became generally known on the continent (largely through the work of Clebsch), they aroused a great deal of interest and they furnished the starting point for many important investigations.

One of the fundamental processes of mathematics is transformation—the deducing of truths from given facts and relations. The expressions which remain invariant when given transformations are performed are naturally objects of great interest and of fundamental importance. Imbued with

*A. B. Kempe, 'How to draw a straight line,' p. 12.

* *Bulletin of the New York Mathematical Society*, 1894, p. 95.

this thought Lie once said, "What do the natural phenomena present to us if it is not a succession of infinitesimal transformations of which the laws of the universe are the invariants?"

It need scarcely be added that all mathematical thought even on the same subject is not running in the same channel. Klein has divided mathematicians into three main categories,* viz, the logicians, the formalists and the intuitionists. The term logician is "intended to indicate that the main strength of the men belonging to this class lies in their logical and critical powers, in their ability to give strict definitions and to derive rigid deductions therefrom. The great and wholesome influence exerted in Germany by Weierstrass in this direction is well known. The formalists among the mathematicians excel mainly in the skillful formal treatment of a given question, in divising for it an algorithm. Gordon, or let us say Cayley and Sylvester, must be ranged in this group. To the intuitionists, finally, belong those who lay particular stress on geometrical intuition, not in pure geometry only, but in all branches of mathematics. What Benjamin Peirce has called 'geometrizing a mathematical question' seems to express the same idea. Lord Kelvin and von Standt may be mentioned as types of this category."

In his address before the Zurich International Congress Poincaré says,† "Mathematics has a triple end. It should furnish an instrument for the study of nature. Furthermore, it has a philosophic end, and, I venture to say an esthetic end. It ought to incite the philosopher to search into the notions of number, space and time; and above all, adepts find in mathematics delights analogous to those that painting and music give. They admire the delicate harmony of numbers and of forms; they are amazed when a new discovery discloses for them an unlooked for perspective; and the joy they experience has it not the esthetic character although the senses take no part in it? Only the privileged few are called to enjoy it fully, it is true, but is it not the same with all the noblest arts? Hence I do not hesitate to say that mathematics deserves to be cultivated for its own sake and that the theories not admitting of application to physics deserve to be studied as well as the others. Moreover, a science produced with a view single to its applications is impossible; truths are fruitful only if they are concatenated; if we cleave to those only of which we expect immediate results the connecting links will be lacking, and there will be no longer a chain."

In closing we may remark that no effort has been made to mention all the new fields of mathematical thought. Mathematics, like the other sciences, seems to offer inexhaustible fields of investigation. As it expands its perimeter increases and hence there is a continually increasing demand for investigators. The fields that have been examined present many difficulties which cannot at present be surmounted. Some of the old difficulties are being removed by the light of the new decoveries. Still we know only a few things even about the fields which have been investigated. It is the exception that something can be done by known methods, the rule is that it cannot yet be done.

When we study the literature of some of the older subjects we are sometimes surprised by the large number of known facts, but when we come to study the subjects themselves and ask independent questions we are generally surprised to learn that so few properties are known. Hence it seems very desirable that the advanced student, at least, should study subjects rather than the known facts in regard to these subjects. In this way a more accurate idea of the

* The *Evanston Colloquium*, p. 2.

† *Revue Générale des Sciences*, vol. 8, p. 857.

true state of knowledge can be obtained. Besides the knowledge of having discovered facts and relations which will enter into the structure of a growing science is the greatest source of pleasure that the student can obtain.

G. A. MILLER.

CORNELL UNIVERSITY,

THE MECHANICS OF SLOW MOTIONS.

THE slow continuous motion of a plastic solid (such as clay, wet sand, wax, tallow, lead, etc.), is a phenomenon of considerable interest to elasticians not only because of the natural interest attaching to this remarkable class of solids, but primarily because it is only during the very slow motions of these solids that it is possible to sharply distinguish them from the class of ultra-viscous liquids. It is possible to conceive of a 'perfectly plastic solid,' which, as an ideal body, is altogether free from viscosity, just as we may conceive of a theoretical elastic solid or of an ideal perfect fluid. It is not so easy, however, to secure experimental data upon which one may base his theoretical investigation of the motions of plastic solids and by which his conclusions may be tested.

It occurred to me a few years ago that the kinetoscope offered a ready means of securing almost any desired magnification of the rate of these slow motions and thus presented to us a method of securing the lines of flow and rates of motion for any desired case. The method that I selected for that purpose was as follows: Let the moving body be photographed upon kinetoscope film at stated intervals—every few minutes, or every few hours, as the case may require. After a sufficient number of these photographs have been obtained, the film may be run through an ordinary projecting kinetoscope at the usual rate. In this way the motion that has required several weeks for its production may be reproduced upon the screen within the limits of a few minutes or seconds. I have magnified in this way the rate of motion about 500,000 fold, but of course there is no major limit to the possible rate of magnification. I made the first application of this method of magnifying slow motions to the motion of growing seedlings. Several peas and beans were placed in a glass root cage containing wet sand. The photographs were taken by artificial light at fixed intervals day and night for about three weeks. When the film is run through the kinetoscope the entire growth for the period of three weeks is reproduced in a few seconds. I found the motions of two peas, which were placed upon the top of the soil, especially interesting. These peas found it almost impossible to get their roots into the soil. In one case the root came out of the top of the pea and made directly for the moist soil. It found this too hard to penetrate, but the root continued to grow, the result being that the pea was rolled about the root cage in a very grotesque manner, the root curving and writhing much like an angle worm struggling to get into the soil.

The kinetoscope also shows very clearly the different speeds at which the various parts of the plant grow, and the different speeds at which the same part grows at different times. The greatest variety in the rate of growth exists, as I suppose is well known, and of course the kinetoscope brings out the relative rates of growth in a very truthful and graphic manner. I regret that my first film does not show any considerable part of the growth of the stems of the plant, as after growing a few centimeters the stems opened the lid of the root cage and passed out of range of the camera.

The rather startling results of this method as applied to growing plants has caused me to give some further attention to the matter. At the present time I am preparing some

additional films taken from growing seeds. Of course there is no reason why the photographing should not be continued until the plants have bloomed and fruited, if any fact important to mechanics or botany is likely to result from the trouble. Perhaps botanists know of matters in plant growth and plant development that it may pay them to investigate by the same method. I anticipate that some interesting facts concerning the mechanics of the root's motion into and through the soil will result from such studies.

I have taken up the work now being done upon living organisms as merely preliminary to the general problem that I have set before me. It must be several months before enough material can be accumulated for a proper discussion of observed and theoretical results in the motions of plastic solids. The actual results may prove disappointing, but this fact cannot be determined in advance.

CHAS. S. SLICHTER.

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*MARYLAND'S HIGHWAY REPORT.**

THERE is a growing realization in this country that the problems which have to be met and solved in the construction of better highways are, in large measure, geological problems. The most satisfactory outcome of this tendency which has yet appeared in this country is the report on highway improvement in Maryland, which has been recently issued by the Maryland Geological Survey; and the Survey, through these investigations and this report, has rendered the cause of good roads in the country at large an important service.

The work resulting in this report was authorized by the General Assembly of Maryland, in an Act passed early in April, 1898, which provided an appropriation of $10,000 per annum for the investigation of questions of road construction in that State, and for the preparation of reports thereon. Under this act a highway division was at once established under the supervision of the State Geologist, Professor W. B. Clark, and Dr. H. F. Reid was appointed chief of this division; Mr. A. N. Johnson, Mr. St. George Lioussat and Mr. F. H. Schloer, special assistants. It was also arranged that other assistants connected with the different branches of the Survey should cooperate in examining the character and distribution in the State of the road-building materials.

Of the volume before us, which contains the results of these investigations, and which it is hoped may serve as a model for similar work in many other States, it is difficult to give any thing like an adequate synopsis in the brief space allotted for an ordinary book review. In a short introductory chapter, Professor Clark has given a copy of the law under which the work was provided for; and a brief statement as to the purpose and character of the enquiries and investigations carried on during 1898 and 1899. This is followed by a more elaborate chapter by Professor Clark on 'the Relations of Maryland Topography, Climate and Geology to Highway Construction'; a subject which must be thoroughly understood by the highway engineer before he can intelligently plan, locate or construct in any section of country, either a system of highways or an individual road. This chapter includes a brief description of the topographical features of the State and its different geographical subdivisions (coastal plain, Piedmont plateau and the Appalachian region), and the influence these have had and should have hereafter on the location of the roads. The question of temperature is not so important a feature in Maryland as in some of the more northern States, for the reason

* Maryland Geological Survey, Vol. III., 1899, pp. 461. Highway Improvement. Baltimore, Md., W. B. Clark, State Geologist.

that the periods of excessively cold weather here occur less frequently and are much shorter in duration than farther north. The normal annual maximum and minimum temperatures are given for the State as 63°F. and 45°F. respectively. As to the question of rainfall and winds, the conditions in Maryland may be considered as a general average of those in the eastern United States; but the rainfall is by no means uniform in different portions of the State, ranging from 31 inches (at one point on the coast) to 53.5 inches at Sunnyside (Garrett county) at an elevation of 2500 feet above sea level.

The relation of Maryland geology to highway construction is discussed in still greater detail in this same chapter, first as relates to the road bed or foundation, and then as to the character and distribution in the State of road materials. The coastal plain region (which comprises nearly 5000 square miles, or a little more than one-half of the land area of the State) contains mainly unconsolidated deposits of sand, clay and loam. In limited areas however, especially in the western and southern portions of this region, there are found ferruginous gravels (of Potomac, Lafayette or Columbia age) which when properly used are found to have good cementing qualities and make fairly satisfactory road surfaces where there is only moderate travel. The marls of this region have not and probably will not be used to any large extent for highway construction, for the reason that the beds are seldom indurated and the shell are quickly ground to pieces under the wheels. Even the calcareous members of the eocene, which are indurated and exposed along many of the valleys, when crushed and placed upon the road surfaces, usually grind rapidly under the wheels and do not recement with sufficient strength to bear heavy and continuous travel. Probably, however, in Maryland as in portions of North Carolina and elsewhere, the more silicious of these beds will be found to possess sufficient hardness as well as cementing qualities to make excellent roads for light travel.

Some 250 miles of oyster-shell roads have been constructed in the region bordering the head of Chesapeake Bay, at a cost of from $1000 to $2000 per mile, and the large oyster interests in the bay will doubtless continue to furnish considerable supplies of this material in the future. Possibly this surface would wear better if with the crushed shell were added a moderate admixture of sand or a thin covering of finely crushed stone. In many portions of eastern Maryland, as indeed over a large portion of the entire coastal plain region of the United States, for the improvement of the ordinary roads in the deep sandy regions, we shall have to depend upon the proper admixture of clay, and the use of wide tires on draught vehicles to prevent the cutting to pieces of these sand-clay roads during wet weather.

In central and western Maryland the question of satisfactory materials for road building is much more easily solved, as suitable materials are much more abundant and widely distributed. The character and distribution of these materials are discussed in detail and their distribution is shown on an excellent map of the State on a scale of 20 miles to the inch. In the Piedmont plateau region are found trap rocks, including gabbro and diabase, widely distributed which are valuable for road purposes on account of their excellent wearing and fair cementing qualites. The granitic and quartzitic rocks, of which some possess fair wearing quality, are the most abundant material in this region. The compact limestones, which are also widely distributed in this region, have in the past (especially the more siliceous beds) constituted a large portion of the road material used. The ig-

neous rocks (which are generally classed as acid and basic volcanics) are limited to the extreme eastern portion of this appalachian region, and have not yet been employed to any considerable extent for highway purposes.

In part VI. of this report, Dr. H. F. Reid describes the qualities of good road metals and the methods of testing them. He classifies the forces tending to destroy roads into two groups:

First, the wear and tear of travel: (1) by blows of the horses' feet; (2) By the blows of the wheels; (3) By the action of the horses' feet in pulling or holding back, tending to pull the stones out of place; (4) By friction of the wheels, especially when trucks are used; (5) By the pressure on the road surface due to the weight of the vehicle and horses.

Second, the forces of nature, under which he includes: (1) Heavy rains which tend to wash the road; (2) The winds which tend to sweep away all the fine material formed on the road surface by travel instead of allowing it to become consolidated again with the mass of the road; (3) The solution and general chemical decomposition of the surface material through the action of water; (4) The changes of temperature; (5) The heaving action of frost and subsequent breaking up of the surface at times of thawing.

Under the 'Methods of testing Road Material,' Mr. Reid describes briefly: (1) the microscopic examination as showing the structure of the rock; (2) abrasion test, which has been so long practiced in France and other countries; (3) the crushing test, which shows the resistance of the rock to crushing action or blows; (4) the cementation test. Of these abrasion and cementation tests are undoubtedly the most important. For many years the French highway engineers depended entirely upon the abrasion test, but one of the important results arrived at through the investigations of the highway laboratory of the Lawrence Scientific School, under Professor Shaler's direction, is the demonstration of the fact, that the cementing power of the road metal, as the surface is ground under the wheels and hoofs, is as important, and in some cases more important than the power of resisting wear; for however hard and tough the road material may be, under the action of the wheels it will be gradually ground into powder, and if it does not possess this cementing power in a high degree, it will be continuously removed from the road surface. With this cementing power developed in a high degree, however, it has been found that fairly soft stone may be used for road surfacing in many cases with decided success.

Part IV., on the present condition of highways in Maryland, by Mr. A. N. Johnson, is of much interest to the student of this great problem of highway improvement in America. Some 2500 miles of these roads were travelled over by Mr. Johnson in carrying on his investigation. The total number of miles of public roads given in Maryland (with a total land area of 9860 square miles) is 14,483; or 1.47 miles of road for each square mile of area. Of this there are 890 miles of stone road, 225 miles of gravel road, 250 miles of shell road, and 13,118 miles of typical American earth road. Of the 890 square miles of stone road about 630 miles were built by turnpike companies and 260 miles have been built by the counties. Unfortunately most of these improved roads were constructed without competent engineering supervision and without proper care as to the grades; and the folly of such practice can not be stated too emphatically nor too often. Perhaps the first urgent need of the typical American highway to-day is that it be properly relocated by a competent engineer before there is any expensive improvement of the surface.

Mr. Johnson also brings out the fact that the average length of the haul for farm products in Maryland, including the distance from farms to the markets and railway stations, is for the State 6.7 miles,

ranging in different counties from four to twelve miles. And he estimates the average cost of hauling one ton one mile in Maryland at twenty-six cents, as compared with an average of twenty-five cents for the United States, from seven to twelve cents in England, France and Germany, and from seven to sixteen cents per ton per mile in New Jersey. In a succeeding chapter which must prove of great value to the people of Maryland, Mr. Johnson discusses the methods of constructing and repairing public roads.

The question of road administration in Maryland and in other States and countries is discussed by Dr. Reid, and a large amount of information concerning this subject, in practically every State of the Union, has been brought together in so careful a manner as to make it of permanent value to the country at large. One is amazed to see that in so few of the States have any practical methods been adopted looking to the permanent betterment of the highways. In this great work New Jersey and Massachusetts have taken the lead in building important highways under State supervision and in part at the State's expense. New York is slowly following in their footsteps. But as we run over the list of other States one is struck with either the practical indifference manifested in the majority of them, except in isolated localities, or else the aimless sort of way in which spasmodic efforts are being made toward the improvement of the public highways over which our rural population must travel and must market its products at a cost approximating $600,000,000 per annum greater than this cost would be if all these important highways were in good condition.

Many facts demonstrating the 'Advantages of Good Roads' are brought out by Dr. Reid in a succeeding chapter. In Part III. on the highway legislation in Maryland and its influence on the economic development of the State, Mr. St. George L. Lioussat has not only brought together a large amount of information relative to highway legislation and the early history of Maryland, but he has presented an ordinarily dry subject in such a way as to make much of it interesting, even to the general reader; especially would this apply to the last few pages of his chapter which treats of the building of the national road, which was constructed by the Federal Government from Cumberland, Maryland, to the Ohio River.

At the end of the volume is an appendix of 76 pages in which are brought together the laws of Maryland relating to highways.

The typography and illustrations of this volume, like those of the preceding volumes of the Maryland Geological Survey, are excellent in both selection and execution. There are 35 half-tone plates and maps illustrative of the various topics treated in the report. The maps, which are exceptionally clear and free from crowding, show the distribution of rainfall, temperature, road materials and the main roads of the State; and in addition to the general maps there are separate county maps which show both the principal roads and the materials which can be used best in improving them.

In concluding this review, already too long, I must call attention to another phase of this good-roads problem, and one which should be taken to heart in all portions of the country. The good people of Maryland, like their fellow citizens in other states, have gone through a century or more without a highway system. During the past ten years they have expended on their highways over $6,000,000, most of it wasted in continually patching more than 13,000 miles of ordinary dirt roads, most of which are poorly located; all of them bad at certain seasons; many of them bad at all seasons. Furthermore, as shown by a careful estimate in this report, the travel-

ing and hauling done over these earth roads by the people of Maryland costs them annually not less than $3,000,000 more than it would cost were the more important of these roads transformed into well built modern highways.

That there exists to-day in so important and intelligent a commonwealth, a condition of affairs so costly, and so unnecessarily bad, a condition which greatly retards the material, social and intellectual development of its rural population especially, is deplorable enough; but a still more unfortunate fact is that, looking over the whole of this great country of ours, there are scarce half a dozen states that claim a better record.

J. A. Holmes.

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS FOR THE YEAR ENDING JUNE 30, 1899.

The report on the work and expenditures of the agricultural experiment stations in the United States for 1899, prepared by Dr. A. C. True, Director of the Office of Experiment Stations, Department of Agriculture, has recently been transmitted to Congress. The general conclusions regarding the present status of the stations are stated in the report in substance as follows:

The work of the stations during the past year has for the most part been along the same lines as heretofore, and in the aggregate a large amount of useful work has been accomplished. By their own efforts and with the aid of the colleges of agriculture and the State boards or commissioners of agriculture, the stations are bringing their work home more closely to the farmers through publications, farmers' institutes, agricultural associations, home reading courses and the press. It is becoming evident that farm practice in this country is being materially affected by the work of the stations, and they are more and more relied upon by our progressive farmers for advice and assistance.

THE FINANCIAL BUSINESS OF THE STATIONS.

The financial business of the stations is now generally conducted systematically and carefully, and with due regard to the limitations of the Hatch Act and the State laws governing their operations. The wisdom of Congress in making the Hatch fund a research fund is every year becoming more apparent. This Department is therefore disposed to more strongly insist on a strict interpretation of this act in this direction, and to hold that it is not only in accordance with the obligation, but also to the interest of the States, to devote the Hatch fund to investigations in agriculture and to supplement this fund as far as may be necessary to promote the interests of agriculture in other lines.

RELATIONS OF COLLEGES AND STATIONS.

The movement for the improvement of courses of agriculture in the colleges with which the stations are connected is steadily growing. The past year has witnessed many changes for the better as regards specialization of the work of instruction and the development of courses suited to the varied needs of students. More then ever before the colleges are reaching out beyond their class rooms and are carrying useful instruction to the farmers through farmers' institutes, correspondence courses, and other forms of so-called university extension. As this outside work becomes better organized, it is more apparent that it belongs to the college rather than the station. At the same time when properly managed it affords efficient means for bringing the results of station work home to the farmer, and thus usefully supplements the publications of the stations. With the return of financial prosperity the States are more liberally endowing the colleges and providing them with better buildings and equipment. As the

stations usually make considerable use of the improved facilities given to the colleges, the means for making their work more efficient have been materially improved during the past year.

As the work of both college and station grows in extent and complexity, it becomes more apparent that in order to perform the most efficient service the station should be organized strictly as a separate department of the institution with which it is connected, and that it should have an organization so compact that its work may proceed in accordance with a schedule carefully planned and energetically administered. To secure this end experience shows that it is quite desirable that the station should have a competent executive officer, who can devote his time very largely to planning and directing its operations, managing its general business, and representing its interests before the public. It is encouraging to observe that in several States during the past year these considerations have led to the more complete separation of the business of the station from the general business of the college, and to the appointment of a director of the station as a separate officer.

THE WORK OF STATION OFFICERS AT FARMERS' INSTITUTES.

One of the most striking evidences of the great awakening of our farmers to the importance of technical education relating to their art is the rapid extension of farmers' institutes in all parts of the country during the past few years. Institutes are now held with more or less regularity in 43 States and Territories. It is estimated that during the past year no less than 2000 institutes were held in the United States, which were attended by 500,000 farmers. As this movement progresses there is an increasing demand for the services of experts at these institutes. The farmers best like to hear those men who have made a thorough study of the subjects of which they treat, and who can impart up-to-date information.

In States where the farmers' institutes have been held for a number of years the farmers who attend them are becoming quite familiar with the general principles of agricultural science and the results of the work of the stations as set forth in their publications. It therefore becomes necessary for the speakers at these institutes to devote more time to the preparation of their lectures in order to successfully meet the needs of progressive farmers and give them new information. This fact, as well as the increasing number of institutes, makes it impracticable for station officers to engage very largely in institute work without detracting from their efficiency as investigators. Moreover, to make the thorough investigations which intelligent farmers now insist upon station officers, must devote themselves very closely to this work. It is, therefore, quite clear that we need in this country to devote a corps of institute workers, who can glean from the work of the stations and other sources the fresh information which our farmers demand and can take the time to attend a considerable number of institutes each year. These men must be well trained in the science and practice of agriculture and at the same time must have peculiar gifts as lecturers before popular assemblies. This would not necessarily mean that the station officers should withdraw wholly from the institutes. Without doubt, it is desirable that they should from time to time meet the farmers in this way, but this work should be kept within such limits that it will be merely incidental to their legitimate business as investigators.

THE STATION PUBLICATIONS.

There is still great variety in the character of the publications issued by the sta-